20000822 163

EEDP-04-13
August 1990

Environmental Effects of Dredging Technical Notes

Environmental Interpretation and Evaluation of Hydrocarbon Contaminants in Dredged Material

Purpose

This note summarizes recommendations of the second petroleum hydrocarbons workshop convened to assist Corps Districts in evaluating hydrocarbon contamination in dredged material.

Background

On 15-17 March 1988, a workshop on environmental interpretation of petroleum hydrocarbons in dredged material was conducted at the US Army Engineer Waterways Experiment Station (WES). Participants represented government agencies, private industry, and academia, and were selected for their expertise in environmental chemistry and biological effects of petroleum hydrocarbons. The work shop was held at the request of US Army Engineer Districts, Chicago and New York, and followed an earlier (1986) workshop on regulatory evaluation of petroleum hydrocarbons in dredged material.

The purpose of the second workshop was to develop guidance on scientific interpretation of potential impacts of polycyclic aromatic hydrocarbons (PAHs) in dredged material. Participants in the 1986 workshop recommended a list of 15 priority pollutant PAHs for regulatory analysis of dredged material. They also recommended a two-tiered testing scheme consisting of first-tier acute toxicity tests and sediment analysis of the 15 PAHs in dredged material, and second-tier 10-day bioaccumulation tests. Roundtable discussions during the second workshop centered on a reexamination of the recommendations of the 1986 workshop, sediment analyses and biological testing for PAHs, and the biological effects of PAHs. Participants recommended no change in the list of 15 PAHs originally

selected for regulatory analysis of dredged material. The original two-tiered testing approach was expanded to a four-tiered approach that conforms to the Federal Standard for dredged material evaluation.

Additional Information or Questions

Refer to the workshop proceedings (Clarke and Jarvis in preparation) or contact the authors, Ms. Susan Jarvis, (601) 634-2804, and Ms. Joan Clarke, (601) 634-2954, or the EEDP Program Manager, Dr. Robert M. Engler, (601) 634-3624.

Summary of Recommendations of the 1986 PAH Workshop

The primary objective of the 1986 workshop was to identify from the myriad of petroleum hydrocarbons, specific compounds that would be most appropriate to analyze in the environmental assessment of dredged material placement. Participants agreed that PAHs are the most important class of hydrocarbons in dredged material due to their toxicity and persistence. Fifteen of the sixteen priority pollutant PAHs were recommended for the evaluation of dredged material: acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[b]-fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]-anthracene, fluoranthene, fluorene, indeno-[1,2,3-cd]pyrene, phenanthrene, and pyrene.* Naphthalene, the sixteenth priority pollutant PAH, was not included in the list because of problems in obtaining accurate analytical results. It is also very volatile and too water soluble to persist in sediments. The behavior, fate, and effects of the 15 selected PAHs were thought to be representative of hydrocarbons known to have biological effects.

A two-tiered testing approach was recommended based on the assumption of a reason to believe that a sediment is contaminated with PAHs. The first tier included acute toxicity testing and chemical analysis for the 15 selected PAHs. If Tier I results demonstrated acute toxicity, it would be unnecessary to continue to Tier II because the sediment would be considered unacceptable for unrestricted placement. If Tier I results indicated the presence of PAH contamination of the sediment, but no acute toxicity occurred, there could still be potential for unacceptable adverse biological effects. Tier II, bioacumulation testing, would then be conducted to assess whether the 15 PAHs accumulate in the tissues of test organisms. If these compounds are not taken up by organisms exposed to the sediment (that is, are not bioavailable), then PAH-related biological impact would be unlikely to occur. Bioaccumulation testing would use organisms such as bivalves that have limited ability to metabolize PAHs and are thus capable of accumulating parent PAH compounds.

---

* Priority pollutants refer to a list of 129 toxic substances compiled by the US Environmental Protection Agency (USEPA). The list includes 16 PAHs.

Future research was recommended to develop analytical procedures and biological testing protocols for evaluating PAH metabolites, alkylated PAH, heterocyclic, nitroaromatics, and aromatic amines. Research and development needs included assays for carcinogenicity, genotoxicity, and reproductive effects. The recommendations and observations of the 1986 workshop are detailed in Clarke and Gibson (1987a, b).

Recommendations of the 1988 PAH Workshop

Reevaluation of 1986 Workshop Recommendations

Participants in the second workshop reexamined the list of 15 PAHs selected in the 1986 workshop for evaluation of dredged material, and generally agreed that the list should remain unchanged. Naphthalene was still excluded from the list because of potential problems in obtaining accurate chemical analysis of this compound from environmental samples. Other suggested additions to the list such as the alkyl-, nitrogen-, and sulfur-substituted PAHs, and benzo[e]pyrene were not accepted because of analytical problems, similarity in effect with PAHs already on the list, or because not enough is yet known about their behavior and biological effects in sediment.

Biological Effects of PAHs

PAHs have been associated with a number of acute and chronic biological effects, including mortality, impairment of growth and reproductive processes, and carcinogenicity/mutagenicity. Mortality may occasionally result from high concentrations of the lower molecular weight, acutely toxic PAH. Acute toxicity from sediment-associated PAH is most likely to occur in aquatic organisms that feed at the sediment surface such as benthic fish, some crustaceans, or deposit-feeding polychaetes since these organisms receive maximum exposure to PAH in the sediment.

Chronic or sublethal effects may result from parent PAH or from biotransformation of the parent PAH compounds to more toxic metabolites. Fishes and some invertebrates generally have well-developed biotransformation capability for PAHs. Among the sublethal effects, adverse impacts on reproduction and growth will likely have the most ecological importance to a population of organisms over time.

PAHs may be linked to carcinogenicity or mutagenicity in susceptible organisms. Of the 15 recommended PAHs, benz[a]anthracene, chrysene, benzo[a]-pyrene, dibenz[a,h]anthracene, benzo[b]fluoranthene, and benzo[k]fluoranthene have shown carcinogenicity in mammalian systems. PAHs that cause cancer in mammals may have a potential for causing cancer in other organisms, because the same mechanisms are involved. Nevertheless, cancer in aquatic populations may

not necessarily be caused only by PAHs, but also by other environmental stresses, especially in industrialized areas where other contaminants are present.

Effects-Based Screening Guidelines

The Chicago and New York District sponsors requested effects-based numeric guidelines or thresholds for PAHs in sediments or in tissues. Each sponsor suggested that these guidelines serve as a screening tool for identifying sediments having sufficiently low or high PAH concentrations to eliminate the need for further testing. However, the workshop participants strongly emphasized that such threshold concentrations could not be recommended because there are no levels of concern for PAHs and not enough information to quantitatively link adverse biological effects with concentrations of PAHs either in sediment or in tissues. Scientifically sound evaluation of PAH-contaminated dredged material must be based on biological testing rather than numeric criteria because of a current lack of understanding of factors influencing bioavailability and toxicity of complex contaminant mixtures in sediments.

Recommendations for a Tiered Testing Approach

An adequate environmental assessment program for dredged material placement should incorporate a suite of tests to assess the potential for various adverse effects of PAHs on species representative of those occurring at the placement site. By arranging the tests in tiers, the evaluator will be able to determine the number and progression of tests needed for a specific project evaluation.

The two-tiered testing approach recommended in the 1986 PAH workshop was expanded to four tiers (Figure 1). Tier I is the determination of a reason to believe that the dredged material is contaminated with PAHs and that the potential exists for unacceptable adverse biological effects as a result of dredging and placement. This assessment could use historic data, knowledge of point sources or spills, or any other relevant information. If there is a reason to believe, or insufficient information for any assessment, then the evaluation would proceed with chemical and biological testing.

Tier II involves chemical analysis of the sediment for the 15 selected PAHs to determine whether the dredged material is more contaminated than the sediment at the placement site environs. If Tier II indicates that there is a potential for unacceptable adverse effects to occur or if Tier II produces insufficient information to determine that potential, then Tier III would be conducted.

Tier III is the first biological testing tier and includes acute toxicity testing using sensitive organisms that are representative of organisms at the placement site environs. Appropriate species could include *Mysidopsis, Palaemonetes, Nereis, Rhepoxynius*, or *Ampelisca* in saltwater, and *Daphnia, Ceriodaphnia, Selenastrum,*

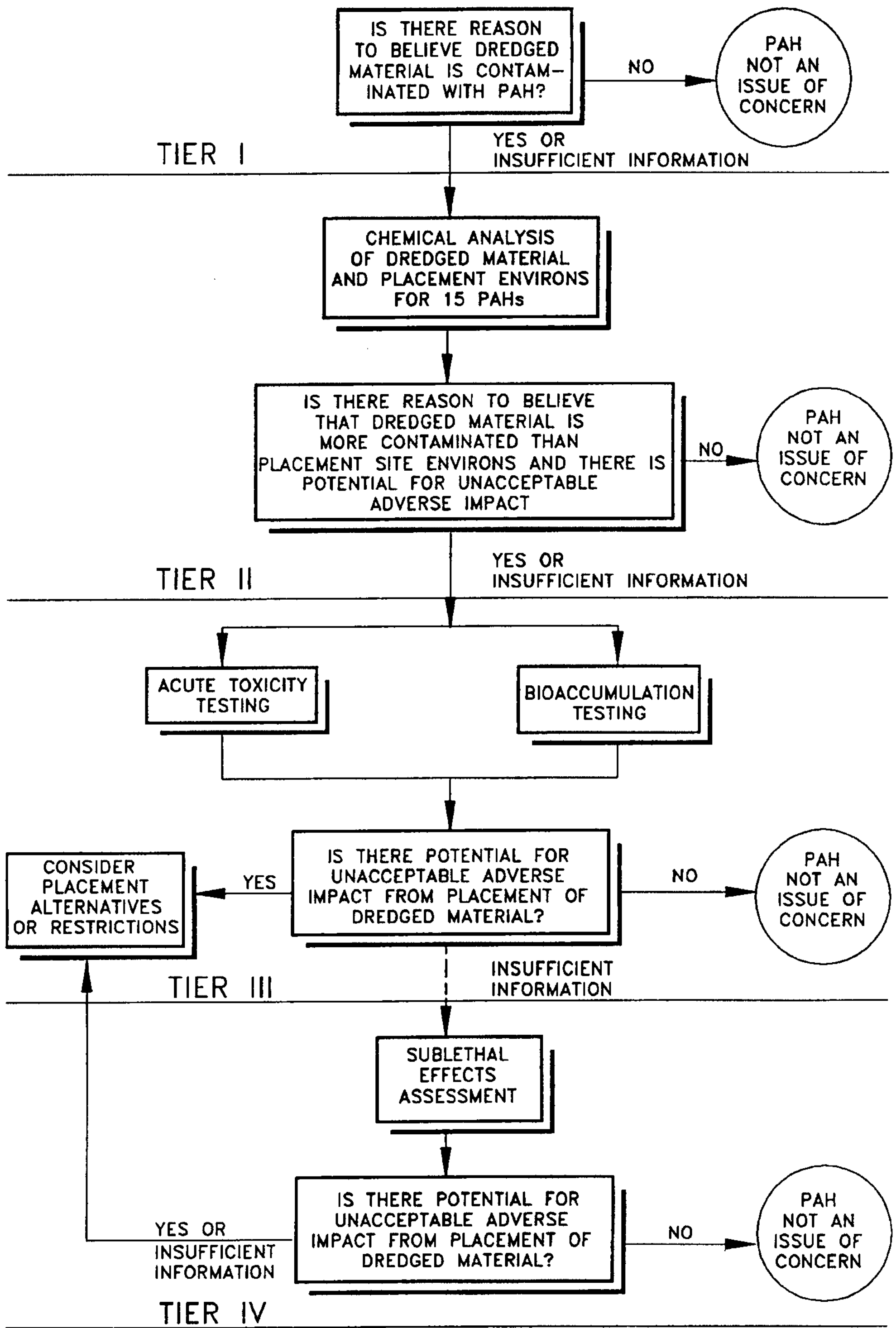

Figure 1. Suggested tiered testing approach, for evaluation of PAHs in dredged material

fathead minnows, *Pontoporeia, Chironomus*, or *Hexagenia* in freshwater. Tier III also includes bioacumulation testing using deposit-feeding organisms that have little metabolic capability for PAHs. Bivalves such as *Macoma* or *Yoldia* are recommended for saltwater, while the Great Lakes amphipod *Pontoporeia* or another amphipod or *Hexagenia* are possibilities for freshwater bioaccumulation tests. As in Tier II, the significance of Tier III results is determined by comparing test results from dredged material to results from the placement site environs.

Results from Tier II and Tier III tests may be difficult to interpret for individual PAHs because of limitations in knowledge concerning the biological effects and relative importance of these individual compounds. A data base needs to be developed relating environmental levels of the 15 PAHs with biological effects. Presently, total PAH as the sum of the 15 PAHs could be used to compare and interpret results. The values generated for the 15 individual PAHs using this approach could be incorporated into the data base, but would not necessarily be used at this time in evaluation.

Tier IV would evaluate the potential for adverse impacts on sublethal effects such as reproduction and growth, perhaps using a partial or whole life-cycle test. The ability of organisms to reproduce successfully is an indication of fitness in the population. Environmental agencies and the scientific community are placing more emphasis on reproductive effects; therefore, reproductive bioassessment will likely become increasingly important in the future. Other possibilities for assessing sublethal effects include biochemical tests, such as enzyme induction, and assays for carcinogenicity or mutagenicity.

A definite need for research in the area of sublethal effects is clear. The workshop participants could not agree on any single test or suite of tests for sublethal effects. Nonetheless, they agreed that any tests adopted must be sensitive to the contaminants in the dredged material to be regulated, and site-specific to the extent that they assess the particular impacts known or suspected in the dredged material. At this time, no PAH sublethal effects tests are sufficiently standardized or verified to meet those criteria. Thus, the suggested four-tiered testing approach is not ready for full implementation. The first three tiers can be implemented now and correspond to the Corps' comprehensive testing strategy for dredged material placement as part of the Federal Standard (Engler and others 1988). Sublethal effects tests (Tier IV) require more research, development, and standardization before being adopted for evaluation of sediment.

The tiered testing approach arising from the PAH workshop should not be considered the final answer to evaluation of PAH-contaminated dredged material. However, it does supply a direction in which Corps Districts may proceed. More research and information are needed to develop a detailed, comprehensive testing approach for PAHs in sediment, particularly when chronic or sublethal effects are of concern. Progress in this direction is being proposed and initiated by the Corps under the Long-Term Effects of Dredging Operations (LEDO) program and the Water Quality Research Program. The ultimate goal is the development of technically sound and feasible guidance on PAHs as well as other contaminants of concern.

References

Clarke, J. U., and Gibson, A. B. 1987a. "Regulatory Identification of Petroleum Hydrocarbons in Dredged Material; Proceedings of a Workshop," Miscellaneous Paper D-87-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Clarke, J. U., and Gibson, A. B. 1987b. "Regulatory Identification of Hydrocarbon Contaminants in Dredged Material," Environmental Effects of Dredging Technical Note EEDP-04-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Clarke, J. U., and Jarvis, A. S. "Environmental Interpretation and Evaluation of Petroleum Hydrocarbons in Dredged Material; Proceedings of a Workshop," Miscellaneous Paper in preparation, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Engler, R. M., Wright, T., Lee, C. R., and Dillon, T. M. 1988. "Corps of Engineers' Procedures and Policies on Dredging and Dredged Material Disposal (The Federal Standard)," Environmental Effects of Dredging Technical Note EEDP-04-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

INTERNET DOCUMENT INFORMATION FORM

A . Report Title: ENVIRONMENTAL INTERPRETATION AND EVALUATION OF HYDROCARBON CONTAMINANTS IN DREDGED MATERIAL

B. DATE Report Downloaded From the Internet: 08/15/00

C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #): **US Army Engineer Waterways Experiment Station**
Environmental Laboratory
PO Box 631
Vicksburg, Mississippi 39181-0631

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
DTIC-OCA, Initials: __LF__ Preparation Date 08/21/00

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.